

Sleep Patterns Before, During, and After Deployment to Iraq and Afghanistan

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Study Objectives: To determine the associations between deployment in support of the wars in Iraq and Afghanistan and sleep quantity and quality.

Design: Longitudinal cohort study

Setting: The Millennium Cohort Study survey is administered via a secure website or US mail.

Participants: Data were from 41,225 Millennium Cohort members who completed baseline (2001–2003) and follow-up (2004–2006) surveys. Participants were placed into 1 of 3 exposure groups based on their deployment status at follow-up: nondeployed, survey completed during deployment, or survey completed postdeployment.

Interventions: N/A

Measurements and Results: Study outcomes were self-reported sleep duration and trouble sleeping, defined as having trouble falling asleep or staying asleep. Adjusted mean sleep duration was significantly shorter among those in the deployed and postdeployment groups compared with those who did not deploy. Additionally, male gender and greater stress were significantly associated with shorter sleep duration. Personnel who completed their survey during deployment or postdeployment were significantly more likely to have trouble sleeping than those who had not deployed. Lower self-reported general health, female gender, and reporting of mental health symptoms at baseline were also significantly associated with increased odds of trouble sleeping.

Conclusions: Deployment significantly influenced sleep quality and quantity in this population though effect size was mediated with statistical modeling that included mental health symptoms. Personnel reporting combat exposures or mental health symptoms had increased odds of trouble sleeping. These findings merit further research to increase understanding of temporal relationships between sleep and mental health outcomes occurring during and after deployment.

Keywords: Sleep, deployment, Millennium Cohort, mental health, veterans

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ACCORDING TO A 2008 REPORT FROM THE NATIONAL SLEEP FOUNDATION, AMERICANS ARE WORKING MORE AND SLEEPING LESS, WITH THE AVERAGE work day lasting 9 hours 28 minutes and time in bed only 6 hours 55 minutes.¹ The US military is at particularly high risk for sleep disturbances due to hazardous working conditions, inconsistent work hours, harsh environments, routine exposure to loud noises, and crowded sleeping spaces.^{2,3} Exposures to these adverse working conditions are often intensified during deployments, including the current increased operational tempo, with lengthy and frequent deployments, as well as demanding training exercises. Deployment-related factors may lead to sleep complaints, including circadian desynchronization, total or partial sleep deprivation, lengthy sleep latency, and waking after sleep onset that may, in turn, exacerbate mental and physical health symptoms following deployment.^{2,3}

The quantity and quality of sleep affect many aspects of physical and mental health.⁴⁻¹² Military personnel deployed in support of Operation Iraqi Freedom and Operation Enduring Freedom may be at increased risk for chronic sleep loss, as well as many other adverse physical and mental conditions, compared with nondeployed military personnel.¹³⁻¹⁵ Sleep deprivation has been studied extensively and is associated with many physical and psychological effects, including increased risk-taking behavior,^{7,11} decreased threat detection,¹⁰ impaired decision making,^{7,11,12} performance degradation,^{4,8,9} mood disturbances,⁸ and tunnel vision.⁶ Short sleep duration has also been associated with obesity, weight gain, and heart disease.^{5,16,17}

A recent cross-sectional study of 156 deployed US Air Force Airmen found that 40% of respondents suffered from at least 1 sleep disturbance, and 75% of respondents reported diminished sleep quality while deployed when compared to sleep quality at home.³ The purpose of this study was to determine any association between deployment in support of the operations in Iraq and Afghanistan and sleep quantity and quality in a large military population. We hypothesized that military personnel who had deployed would have more trouble sleeping and sleep less than those who have not deployed. The Millennium Cohort Study¹⁸ includes all Service branches of the US military, active-duty, Reserve, and National Guard personnel. A substantial proportion (22%) of cohort members were deployed in support of the operations in Iraq and Afghanistan between baseline and

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follow-up surveys. This population provided valuable information on sleep patterns, as well as behavioral, occupational, and demographic characteristics among participants who completed their survey during and after deployment.

METHODS

Study Population and Data Sources

Data for these analyses were from the first enrollment panel (Panel 1) of the Millennium Cohort Study,¹⁸ launched in 2001, prior to the current operations in Iraq and Afghanistan. Subsequent enrollment (Panels 2 and 3) has resulted in a total study population of over 150,000 cohort members. Panel 1 is composed of a population-based sample of 77,047 people, including members from all Service branches, as well as Reserve and National Guard members. Several groups were oversampled, including those previously deployed to Southwest Asia, Bosnia, or Kosovo from 1998 to 2000, Reserve/Guard personnel, and female Service members, to ensure adequate statistical power to draw meaningful inferences in these important subgroups of the population. Millennium Cohort participants are surveyed every 3 years. The questionnaire gathers a wide range of data regarding physical and mental health, deployment and deployment-related exposures, occupation, women's health, demographics, and behavioral health including sleep, smoking, alcohol, physical activity, and use of complementary and alternative therapies.^{18,19}

In mid-2001, over 214,000 personnel on military rosters were contacted and invited to participate in the first panel of the Millennium Cohort; 77,047 (36%) were enrolled from 2001 to 2003. Of these individuals, 55,021 (71%) completed a follow-up questionnaire from 2004 to 2006. Individuals who deployed before the baseline assessment or who took their baseline survey while deployed were excluded from these analyses ($n = 2222$). Additionally, participants missing any information on demographic, military, health, or behavioral characteristics at baseline or follow-up were excluded ($n = 11,574$), allowing for a final study population of 41,225.

Deployment dates were provided by the Defense Manpower Data Center. Participants were placed into 1 of 3 deployment categories based on submission of their follow-up survey in relation to their deployment dates. Participants placed in the "nondeployed" category had not deployed at the time of their follow-up survey submission. Participants placed in the "post-deployment" category returned from deployment at least 2 weeks prior to submitting their follow-up survey. By allowing a 2 week lag time we could account for the reporting period for the sleep duration question, which asks for the number of hours of sleep in an average 24-h period over the past month. Therefore, if a participant returned from deployment at least 2 weeks prior to completing the questionnaire, the most recent portion and at least half of the reporting period would have occurred following the deployment. The "deployed" group consisted of participants who submitted their follow-up survey during deployment or individuals who returned from a deployment less than 2 weeks before submitting their follow-up survey.

Baseline military and demographic information included sex, birth year, education, race/ethnicity, marital status, service branch and component, military pay grade, and occupation (see Table 1 for subgroup categories). For regression analyses, birth

year was categorized into 4 groups: 1960 and before, 1960-1969, 1970-1979, 1980 and later. Self-reported behavioral characteristics were assessed from the Millennium Cohort questionnaire. History of potential alcohol dependence was evaluated using the CAGE (Cutting down, Annoyance by criticism, Guilty feeling, and Eye-openers)²⁰ responses, where at least 1 positive response represented potential problems with alcohol. Current smokers were identified as individuals who reported smoking at least 100 cigarettes in their lifetime and had not tried, or were unsuccessful at, quitting. Current smokers were compared with past and nonsmokers. Body mass index (weight [kg]/height [m²]) was categorized according to the Centers for Disease Control and Prevention standardized cut points to classify individuals as underweight (< 18.5), healthy weight ($18.5-24.9$), overweight ($25.0-29.9$), and obese (≥ 30.0) and analyzed using these categories for regression analyses. Life stressors, including divorce, bankruptcy, sexual assault or harassment, violence, death of a loved one, or illness or injury were assessed using scoring mechanisms adapted from the Holmes and Rahe Social Readjustment Rating Scale.²¹ In addition, the questionnaire includes a history of provider-diagnosed sleep apnea.

Standardized instruments were used to assess mental health disorders at baseline and at follow-up. Posttraumatic stress disorder (PTSD) symptoms were quantified using the PTSD Checklist-Civilian Version (PCL-C). The PCL-C is a 17-item questionnaire used to assess the severity of avoidance, hyperarousal, and intrusion symptoms. A participant was defined as having PTSD symptoms if at least 3 avoidance symptoms, 2 hyperarousal symptoms, and 1 intrusion symptom are endorsed at "moderate" or higher levels.²² Depression, other anxiety, and panic disorder symptoms were assessed according to Patient Health Questionnaire (PHQ) scoring algorithms.²³ Additionally, combat-related exposures were assessed at follow-up. Combat exposure was defined by at least 1 positive response to questions that asked whether participants had personally (1) witnessed a death due to war, disaster, or tragic event; (2) witnessed instances of physical abuse, (3) been exposed to dead or decomposing bodies, (4) been exposed to maimed soldiers or civilians, or (5) been exposed to prisoners of war or refugees.

Mothers of young children or pregnant women were identified within the Cohort. Mothers of young children were defined as women who reported giving birth within the last 3 years at baseline or follow-up. Pregnant women were those who reported not having menstrual periods at follow-up due to pregnancy or recent childbirth.

Outcomes

Sleep duration

The questionnaire contains a single question that asks "Over the past month, how many hours of sleep did you get in an average 24-hour period?" Participants were able to write in their sleep duration, rounded to the nearest hour. Sleep duration was assessed as a continuous variable.

Sleep disorders

Trouble sleeping during a 1-month time frame was assessed at follow-up using questions from both the PHQ for anxiety and the PCL-C. The PHQ asks, "Over the last 4 weeks, how often

Table 1—Demographic, behavioral, and military characteristics by deployment status of 41,225 Millennium Cohort members

	No Deployment Before Follow-up Survey*	Follow-up Survey During Deployment*	Follow-up Survey Postdeployment*
	n = 30,190	n = 1771	n = 9264
Baseline Characteristics	n (%)	n (%)	n (%)
Sex: Male	21,432 (71.0)	1496 (84.5)	7640 (82.5)
Age (mean)	35.7	32.2	33.1
Race/ethnicity			
White, non-Hispanic	21,780 (72.1)	1206 (68.1)	6570 (70.9)
Black, non-Hispanic	3526 (11.7)	192 (10.8)	966 (10.4)
Other	4884 (16.8)	373 (21.1)	1728 (18.7)
Marital status			
Married	20,465 (67.8)	1150 (64.9)	6066 (65.5)
Never married	7525 (24.9)	538 (30.4)	2614 (28.2)
Divorced, widowed, separated	2200 (7.3)	83 (4.7)	584 (6.3)
Service component: Active duty	15,946 (52.8)	976 (55.1)	5714 (61.7)
Military pay grade: Enlisted	21,639 (71.7)	1299 (73.3)	6770 (73.1)
Self-reported general health			
Fair/poor	2249 (7.5)	106 (6.0)	511 (5.5)
Good	9186 (30.4)	508 (28.7)	2698 (29.1)
Very good/excellent	18,755 (62.1)	1157 (65.3)	6055 (65.4)
Life stressors†			
Low/mild	25,234 (83.6)	1539 (86.9)	8134 (87.8)
Moderate	4022 (13.3)	203 (11.5)	977 (10.6)
Major	934 (3.1)	29 (1.6)	153 (1.6)
Posttraumatic stress disorder	1170 (3.9)	64 (3.6)	265 (2.9)
Depression	870 (2.9)	50 (2.8)	183 (2.0)
Anxiety	554 (1.8)	28 (1.6)	136 (1.5)
Panic	356 (1.2)	15 (0.8)	62 (0.7)
Sleep apnea	840 (2.8)	32 (1.8)	200 (2.2)
Body mass index (mean)	26.1	26.1	26.0
Current smoker	4395 (14.6)	330 (18.6)	1549 (16.7)
Problem drinker‡	5589 (18.5)	368 (20.8)	1770 (19.1)
Follow-up Characteristics			
Combat§	NA	1010 (57.0)	4690 (50.6)
Posttraumatic stress disorder	1273 (4.2)	96 (5.4)	448 (4.8)
Depression	939 (3.1)	63 (3.6)	253 (2.7)
Anxiety	675 (2.2)	43 (2.4)	201 (2.2)
Panic	505 (1.7)	13 (0.7)	155 (1.7)
Children¶	1466 (16.7)	41 (14.9)	192 (11.8)

*At submission of follow-up survey, those in the nondeployed group had not yet deployed, those in the postdeployment group had completed at least 1 deployment, and those in the deployed group were currently deployed.

†History of life stress, including items such as divorce, assault, or having a family member die, was assessed by applying scoring mechanisms from the Holmes and Rahe Social Readjustment Rating Scale.

‡Problem drinking is defined as at least 1 positive response to the CAGE questions (Cutting down, Annoyance by criticism, Guilty feeling, and Eye-openers).

§At follow-up, had personally experienced combat or a combat-like situation, such as witnessing a person's death due to war, disaster, or tragic event.

¶Frequencies of women reporting having children in the last 3 years at baseline and follow-up.

have you experienced trouble falling asleep or staying asleep?" Possible responses included "not at all," "several days," or "more than half the days." The PCL-C asks, "In the past month, have you had trouble falling asleep or staying asleep?" The respondent is able to mark "not at all," "a little bit," "moderately," "quite a bit," or "extremely." A single dichotomous variable was created combining the 2 questions. Participants with

trouble sleeping were defined as those who responded "moderately," or above on the PCL-C sleep item or "several days" or longer on the PHQ anxiety sleep item.

Statistical Analyses

Chi-square tests of association were used to assess unadjusted relationships between trouble sleeping and all covariates.

Table 2—Adjusted mean sleep duration (h) at follow-up (July 2004–January 2006) of Millennium Cohort participants

Characteristics	Mean sleep duration at follow-up n = 38,435	
	Hours	P-value
Model A*		
Deployment Status†		< 0.01
Non Deployed	6.56 ^a	
Post deployment	6.47 ^b	
Deployed	6.46 ^b	
Model B‡		
Deployment status†		0.84
Non deployed	6.33 ^a	
Post deployment	6.33 ^a	
Deployed	6.31 ^a	
Combat§¶		< 0.01
No	6.40 ^a	
Yes	6.25 ^b	
Posttraumatic stress disorder¶		< 0.01
No	6.54 ^a	
Yes	6.11 ^b	
Depression¶		0.07
No	6.37 ^a	
Yes	6.29 ^a	
Anxiety¶		< 0.01
No	6.44 ^a	
Yes	6.21 ^b	
Panic¶		0.21
No	6.36 ^a	
Yes	6.29 ^a	

*Adjusted for sex, birth year, race/ethnicity, education, marital status, service branch, service component, pay grade, occupation, general health, life stressors, baseline sleep duration, sleep apnea, BMI, smoking status, problem drinking, and baseline symptoms of PTSD, depression, anxiety, and panic.

†At submission of follow-up survey, those in the nondeployed group had not yet deployed, those in the post deployment group had completed at least one deployment, and those in the deployed group were currently deployed.

‡Adjusted for all variables displayed in Model A and combat, follow-up symptoms of PTSD, depression, anxiety, and panic.

§At follow-up, had personally experienced combat or combat-like situation such as witnessing a person's death due to war, disaster or tragic event.

¶Assessed at follow-up.

Baseline and follow-up unadjusted mean sleep durations were calculated across the 3 deployment groups. In the multivariable analyses, interactions were tested between deployment and service, sex, and symptoms at follow-up of PTSD, depression, anxiety, and panic, where $\alpha = 0.05$. Collinearity was evaluated among all independent variables.

The main analyses for this study examined 2 outcomes assessed at follow-up, sleep duration and trouble sleeping, using multivariable modeling techniques that adjusted for all demographic, military, health, and behavioral variables measured at the baseline assessment. Sleep duration, a continuous outcome, was

examined using analysis of covariance (ANCOVA) while adjusting for baseline sleep duration in addition to the other covariates. Pairwise comparisons of adjusted mean sleep duration between each category of the covariates were performed using the Tukey-Kramer test statistic.²⁴ Trouble sleeping, a dichotomous outcome (yes vs no), was examined using multivariable logistic regression. Further analyses were performed to examine whether inclusion of mental health symptoms and combat exposures assessed at follow-up affected the associations between deployment and the outcomes of sleep duration and trouble sleeping.

The study had approval from the San Diego State University and the Naval Health Research Center Institutional Review Boards, and informed consent was obtained from all subjects. Data management and statistical analyses were performed using SAS statistical software, version 9.2 (SAS Institute, Inc., Cary, North Carolina).

RESULTS

The demographic characteristics of the study participants at baseline and follow-up are shown in Table 1. Of the 41,225 participants included in these analyses, 30,190 had not deployed at the time they submitted their follow-up survey, 9264 had completed at least 1 deployment before submitting their follow-up survey, and 1771 completed their follow-up survey during deployment. While the demographic distribution across the 3 deployment groups was similar overall, some differences were noted. The nondeployed group was older and had a higher proportion of women when compared to the deployed and postdeployment groups. In addition, the deployed group was comprised of almost 80% Army, while the nondeployed and postdeployment groups were about 50% Army (see Table S1, available online only at www.journalsleep.org).

Unadjusted mean sleep duration was comparable across the three deployment groups for most covariates (data not shown), with average sleep duration approximately 6.5 h and very little to no difference between baseline and follow-up measures. Those with the shortest unadjusted sleep duration had current or past deployment experience and symptoms of PTSD, depression, anxiety, or panic at the follow-up assessment. Similarly, proportions of unadjusted self-reported trouble sleeping were comparable across deployment groups with between 20% and 30% of the population, for most baseline characteristics, reporting trouble sleeping (data not shown). Based on chi-square tests of association, in general, a higher proportion of individuals reporting symptoms of PTSD, depression, anxiety, or panic also reported trouble sleeping, and these proportions were slightly higher among individuals with these symptoms at follow-up than at baseline.

Based on ANCOVA regression modeling, adjusted average sleep duration varied by deployment category (Table 2, Model A). Those in the deployed and postdeployment groups reported significantly shorter sleep duration than the nondeployed group. However, adjusted mean sleep duration for the deployed and postdeployment groups were not significantly different from each other. Average sleep duration for the nondeployed, post-deployment, and deployed groups were 6.56, 6.47, and 6.46 h, respectively, after adjusting for covariates measured at baseline. Pairwise comparisons showed that those reporting significantly shorter sleep duration were more likely to be male, born

Table 3—Adjusted* odds of follow-up trouble sleeping among Millennium Cohort participants

Deployment Status†	n = 38,435	
	AOR	95% CI
Non Deployed	1.00	
Post deployment	1.21	(1.14, 1.29)
Deployed	1.28	(1.14, 1.43)

CI, confidence interval; AOR, adjusted odds ratio.

*Adjusted for sex, birth year, race/ethnicity, education, marital status, service branch, service component, pay grade, occupation, general health, life stressors, baseline sleep duration, sleep apnea, BMI, smoking status, problem drinking, and baseline symptoms of PTSD, depression, anxiety, and panic.

†At submission of follow-up survey, those in the nondeployed group had not yet deployed, those in the post deployment group had completed at least one deployment, and those in the deployed group were currently deployed.

in 1960 or later, black non-Hispanic, serving in the Army or Marine Corps, active-duty members, electronic equipment repair specialists, in good or fair/poor general health, overweight, current smokers, or had experienced moderate or major life stressors (Table S2, available online only at www.journalsleep.org). After adding the potential mediators of follow-up mental health, and combat variables to the model (Table 2, Model B), adjusted average sleep duration was 6.31 to 6.33 h across the 3 deployment groups. Additionally, those reporting symptoms of PTSD or anxiety and those reporting combat exposures had the shortest adjusted sleep duration. Baseline and follow-up mental health variables were not collinear with each other (variance inflation factor < 4). Additionally, sex and the follow-up mental health variables did not modify the relationship between sleep duration and deployment ($P > 0.05$).

Results from multivariable logistic regression modeling the trouble sleeping outcome (Table 3) showed that the adjusted odds for reporting trouble sleeping were significantly increased for personnel in the deployed or postdeployment groups when compared to the nondeployed group. Additionally, smoking (odds ratio [OR] 1.16, 95% confidence interval [CI] 1.01, 1.24) and problem drinking (OR 1.50, 95% CI 1.41, 1.59) were independent predictors of trouble sleeping. Those with the highest adjusted odds of reporting trouble sleeping were individuals who reported baseline mental health symptoms and those who reported fair/poor general health (Table S3, available online only at www.journalsleep.org). Members of the Reserve/Guard, officers and race/ethnicities other than white, non-Hispanic, had significantly reduced odds of reporting trouble sleeping.

Follow-up anxiety symptoms modified the relationship between deployment status and trouble sleeping ($P = 0.01$), so the logistic regression model adjusting for follow-up mental health and combat exposures was stratified by presence or absence of anxiety or panic symptoms. Participants reporting anxiety or panic symptoms at follow-up were combined because all deployers with panic symptoms at follow-up also reported trouble sleeping. Among participants who did not report symptoms of anxiety or panic at follow-up, the highest adjusted odds of trouble sleeping were reported by those concurrently reporting symptoms of other

Table 4—Adjusted* odds of follow-up trouble sleeping among Millennium Cohort participants

Follow-Up Characteristics	No Symptoms of Anxiety or Panic n = 37,249		Symptoms of Anxiety or Panic n = 1,186	
	AOR	95% CI	AOR	95% CI
Deployment status†				
Non deployed	1.00		1.00	
Post deployment	0.91	(0.84, 0.99)	0.89	(0.43, 1.81)
Deployed	0.97	(0.84, 1.11)	1.28	(0.33, 4.93)
Combat‡				
No	1.00		1.00	
Yes	1.61	(1.45, 1.78)	1.44	(0.63, 3.32)
Posttraumatic stress disorder				
No	1.00		1.00	
Yes	12.91	(10.54, 15.81)	3.88	(2.24, 6.75)
Depression				
No	1.00		1.00	
Yes	12.42	(9.29, 16.60)	2.84	(1.60, 5.07)

CI, confidence interval; AOR, adjusted odds ratio.

*Adjusted for all other variables in table, plus sex, birth year, race/ethnicity, education, marital status, service branch, service component, pay grade, occupation, general health, life stressors, baseline sleep duration, sleep apnea, BMI, smoking status, problem drinking, and baseline symptoms of PTSD, depression, anxiety, and panic.

†At submission of follow-up survey, those in the nondeployed group had not yet deployed, those in the post deployment group had completed at least one deployment, and those in the deployed group were currently deployed.

‡At follow-up, had personally experienced combat or combat-like situation such as witnessing a person's death due to war, disaster or tragic event.

mental health disorders (Table 4). Also, those in the postdeployment group had significantly reduced adjusted odds of reporting trouble sleeping compared to those not deployed. Among participants who did report symptoms of anxiety or panic at follow-up, the highest adjusted odds of trouble sleeping were reported by those with follow-up mental health symptoms, but to a much lesser degree than those without anxiety or panic.

A separate sub-analysis of mothers of young children and pregnant women was conducted. In this population, adjusted sleep duration varied significantly based on deployment group (data not shown), with nondeployed compared to postdeployment mothers and pregnant women reporting significantly longer sleep (5.84 vs. 5.58 h, $P < 0.01$) and marginally significantly longer sleep comparing nondeployed to those deployed (5.84 vs. 5.45 h, $P = 0.06$). Adjusted mean sleep duration did not differ significantly between deployment and postdeployment. Results for mothers of young children and pregnant women (Table 5) were similar to the larger population with respect to the relationship between trouble sleeping and mental health disorders. Those reporting follow-up symptoms of PTSD, depression, anxiety, and panic had higher odds of trouble sleeping than those with no mental health symptoms; however, deployment status was not significantly associated with trouble sleeping in these women.

Table 5—Adjusted odds of trouble sleeping among mothers of young children and pregnant women, the Millennium Cohort study (July 2004-January 2006)

Characteristics	n = 2,790	
	AOR	95% CI
Model A*		
Deployment status [†]		
Non Deployed	1.00	
Post deployment	1.29	(1.00, 1.66)
Deployed	1.43	(0.86, 2.38)
Model B[‡]		
Deployment status [†]		
Non Deployed	1.00	
Post deployment	0.97	(0.68, 1.38)
Deployed	1.04	(0.57, 1.89)
Posttraumatic stress disorder [§]		
No	1.00	
Yes	7.14	(3.98, 12.79)
Depression [§]		
No	1.00	
Yes	7.12	(3.40, 14.89)
Anxiety [§]		
No	1.00	
Yes	10.71	(4.36, 26.32)
Panic [§]		
No	1.00	
Yes	3.61	(1.68, 7.78)

CI, confidence interval; AOR, adjusted odds ratio.

*Adjusted for sex, birth year, race/ethnicity, education, marital status, service branch, service component, pay grade, occupation, general health, life stressors, baseline sleep duration, sleep apnea, BMI, smoking status, problem drinking, and baseline symptoms of PTSD, depression, anxiety, and panic.

[†]At submission of follow-up survey, those in the nondeployed group had not yet deployed, those in the post deployment group had completed at least one deployment, and those in the deployed group were currently deployed.

[‡]Adjusted for all variables displayed in Model A and combat, follow-up symptoms of PTSD, depression, anxiety, and panic.

[§]Assessed at follow-up.

DISCUSSION

To our knowledge, this is the first study to prospectively examine the sleep patterns of military service members, in relation to deployment, from all branches and components of the service. Millennium Cohort data allowed for the unique opportunity to examine the sleep of military service men and women at 2 points in time across different deployment experiences. This was an exploratory investigation to characterize sleep patterns among Cohort participants and to determine whether any subgroups of the population, particularly while deployed, are at increased risk for sleep problems.

Our findings suggest that the current deployments do affect sleep as those who were deployed or had returned from a deployment had significantly shorter adjusted sleep duration and increased adjusted odds of reporting trouble sleeping compared

with those who had not deployed. Deployment status, however, did not significantly affect sleep duration in the models that adjusted for follow-up mental health conditions and combat exposures. Additionally, in stratified analyses, deployment status resulted in significantly reduced odds of reporting trouble sleeping among those in the postdeployment group with no symptoms of anxiety or panic at follow-up. These findings suggest that the relationships between deployment and sleep duration and trouble sleeping are mediated by the effects of combat exposures and mental health symptoms.

Adjusted average sleep time was fairly short, with almost every subgroup of the study population reporting approximately 6.5 hours. Research suggests that moderate sleep restriction (limiting sleep to 5 to 7 h per night) may have lasting effects on performance that cannot be quickly recovered.⁹ In contrast, those with extreme sleep deprivation (less than 3 hours per night for 7 days), are able to return to near normal performance after 3 nights of recovery sleep.⁹ Thus, as long as there is time to recuperate, even extreme sleep deprivation on an intermittent basis may not be detrimental to combat troops. Additionally, participants who reported combat exposures had an adjusted average sleep duration of 6.25 hours, which is lower than both the deployed and postdeployment groups. Combat deployers also had significantly increased odds of reporting trouble sleeping among those deployed and those returning from deployment. This is not surprising, as combat and deployment environments can be physically and mentally demanding. The statistically significant difference in adjusted sleep duration between those with combat experience and those without was 9 minutes and may not be clinically relevant. However, those who reported combat were 52% to 74% more likely to also report trouble sleeping when compared to those with no combat experience. Those reporting PTSD symptoms at follow-up were sleeping 26 minutes less per day than those not reporting symptoms, which may be clinically relevant, but many subgroups of the population, despite being significantly different, had average sleep durations that differed by less than 15 minutes.

Sleep disturbances commonly co-occur with mental health conditions.²⁵⁻²⁷ Whether sleep disturbance is a precursor or consequence of certain mental health conditions is unclear. Recent findings, however, suggest that those with insomnia are at increased risk of developing depression and that insomnia is comorbid with, rather than secondary to, depression.²⁶ Similarly, sleep disturbance has been shown to be a core feature of PTSD, rather than a consequence of this disorder.²⁷ Individuals reporting diminished quality of life have also been shown to report more sleep disturbances.²⁸ The high odds of trouble sleeping among those with mental health disorders and lower self-rated general health is supported by similar findings in a large military cohort. Among the US general population, those sleeping less than 7 hours or more than 9 hours had increased odds of depression when compared to those sleeping 7 hours.²⁹ Similarly, those sleeping more or less than 7 hours had increased odds of anxiety when compared to those sleeping 7 hours.²⁹ The reported increases in mental health morbidities among deployers, especially those experiencing combat, has raised long-term health concerns for warfighters.¹³⁻¹⁵ Approaches to enhancing or increasing the quality and duration of sleep during deployment

deserves further investigation as a possible means to potentially reduce the occurrence of comorbid mental health disorders.

Trouble sleeping was found to occur at follow-up in 25.0% of those who had not deployed, 30.5% of those who completed their follow-up survey during deployment, and 27.1% of those who completed their follow-up survey postdeployment. Many of the characteristics that were associated with longer sleep durations (Table S2, available online only at www.journalsleep.org) were also associated with higher odds of trouble sleeping (Table S3, available online only at www.journalsleep.org). For example, women reported significantly longer sleep duration than men (6.56 hrs vs. 6.44 h), but women also had higher odds (OR 1.56, 95% CI 1.45, 1.67) of trouble sleeping. This discordance between sleep duration and trouble sleeping may suggest that those who have the most trouble sleeping are spending more time in bed trying to fall asleep or are taking medication to help them sleep.

The large number of mothers with young children and pregnant women ($n = 2790$) in our study allowed an analysis of sleep measures in this unique military subpopulation. Adjusted mean sleep duration in this population (5.84 hours for nondeployed, 5.58 for those postdeployment, and 5.45 for those deployed) was almost 1 hour shorter than women in general (6.56 h). Pregnant women with mental health symptoms at follow-up were also significantly more likely to report trouble sleeping (Table 5) than pregnant women who did not indicate symptoms of mental health disorders. These results were similar, although smaller in magnitude, to those seen in the regression analyses for the entire study population. Studies looking at the civilian population³⁰⁻³⁴ have also noted that new mothers and pregnant women report more sleep problems and shorter sleep durations than other women, with mean sleep durations in these studies ranging from 6.5-7.5 hours.³¹⁻³³ The current study reports a similar unadjusted sleep duration (6.7 h) but much lower duration after adjusting for other variables in the model (5.45-5.84 h). Varying study methods may account for some of these discrepancies, but it is also probable that the normal stressors of impending/new motherhood may be increased in military women who have the possibility of future deployments and separation from their families. Sleep problems may be a symptom of mental health disorders and other comorbidities in this subgroup and warrants more focused research on parental stress in the context of military deployment.

This study has limitations. Self-reported data are subject to recall bias, may lack precision, and, thus, may not be a valid measure of actual sleep duration.^{35,36} Research has shown that self-reported duration of sleep overestimates actual sleep time by approximately 1 hour when compared with sleep measured by wrist actigraphy.³⁶ Also, sleep duration was measured in whole number increments, similar to other cohort studies,^{29,37,38} and might result in a loss of precision and possibly affect the ability to detect differences between groups. In this study, it was not possible to determine if short sleep durations were caused by insomnia versus the effect of a busy schedule that does not allow for longer sleep times. In addition, it was not possible to adjust for several influential variables that could affect sleep patterns, such as prescribed sleep medications, other medications with sleep related side effects, and stimulants (e.g., caffeine), since these data were not available. Although of interest,

it was also not possible to investigate sleep patterns among specific occupational groups that may have a greater propensity for disruption of normal sleep patterns, such as submarine crew members while underway.

Despite these limitations, there were several strengths. The Millennium Cohort represents all Service branches and components of the US military, including active duty and Reserve/Guard personnel. The large sample size allows for robust comparisons and the ability to detect small differences in subgroups of our study population. Thorough evaluations of possible biases suggest the Cohort is representative of military personnel in terms of demographic and mental health characteristics and that participants report health and exposure data reliably.^{18,39-41} Finally, the Cohort questionnaires measure sleep in several different ways, permitting assessment of the outcome from several perspectives.

In conclusion, deployment status was significantly associated with shorter self-reported average sleep duration and increased trouble sleeping. Additionally, exposure to combat during deployment was an independent predictor of both shorter sleep duration and trouble sleeping. Commanders, medical providers, and military personnel should be aware of the increased risk for sleep disturbance among those who display symptoms of PTSD, depression, anxiety or panic, and among those with combat exposure. Our findings also suggest that follow-up symptoms of mental health and combat exposures mediate the relationship between deployment and sleep. A more in-depth look at possible short- and long-term health outcomes among those reporting the shortest sleep durations and among mothers and pregnant women is recommended. If poor sleep contributes to the occurrence, persistence, or severity of mental health disorders or poor job performance, then the promotion of healthier sleep patterns, including recovery time following extreme sleep deprivation, among military service members may be beneficial in this population.

DISCLAIMER

The views expressed in this work are those of the authors, and do not reflect the official policy or position of the Department of the Navy, Department of the Army, Department of the Air Force, Department of Defense, or the US Government. The funding organization (Military Operational Medicine Research Program) had no role in the design and conduct of the study; collection, analysis, or preparation of data; or preparation, review, or approval of this manuscript. VA Puget Sound Health Care System provided support for Dr. Boyko's participation in this research.

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Table S1—Demographic, behavioral, and military characteristics by deployment status of 41,225 Millennium Cohort members

	No Deployment Before Follow-up Survey* n = 30,190 n (%)	Follow-up Survey During Deployment* n = 1771 n (%)	Follow-up Survey Postdeployment* n = 9264 n (%)
Baseline Characteristics			
Sex: Male	21,432 (71.0)	1496 (84.5)	7640 (82.5)
Age (mean)	35.7	32.2	33.1
Birth year			
Pre-1960	8410 (27.9)	242 (13.7)	1599 (17.3)
1960-1969	12,244 (40.5)	749 (42.3)	3834 (41.4)
1970-1979	8488 (28.1)	677 (38.2)	3316 (35.8)
1980 and later	1048 (3.5)	103 (5.8)	515 (5.5)
Race/ethnicity			
White, non-Hispanic	21,780 (72.1)	1206 (68.1)	6570 (70.9)
Black, non-Hispanic	3526 (11.7)	192 (10.8)	966 (10.4)
Other	4884 (16.8)	373 (21.1)	1728 (18.7)
Highest educational level			
Less than high school	1633 (5.4)	133 (7.5)	447 (4.8)
High school diploma/equivalent	11,308 (37.5)	854 (48.2)	3662 (39.5)
Some college	7628 (25.3)	326 (18.4)	2587 (27.9)
Bachelor's degree	5836 (19.3)	332 (18.8)	1815 (19.6)
Advanced degree	3785 (12.5)	126 (7.1)	753 (8.2)
Marital status			
Married	20,465 (67.8)	1150 (64.9)	6066 (65.5)
Never married	7525 (24.9)	538 (30.4)	2614 (28.2)
Divorced, widowed, separated	2200 (7.3)	83 (4.7)	584 (6.3)
Service branch			
Army	14,380 (47.6)	1392 (78.6)	4302 (46.4)
Air Force	8254 (27.3)	172 (9.7)	3278 (35.4)
Navy and Coast Guard	6299 (20.9)	136 (7.7)	1217 (13.1)
Marine Corps	1257 (4.2)	71 (4.0)	467 (5.1)
Service component: Active duty	15,946 (52.8)	976 (55.1)	5714 (61.7)
Military pay grade: Enlisted	21,639 (71.7)	1299 (73.3)	6770 (73.1)
Occupation			
Combat specialists	5749 (19.0)	489 (27.6)	2296 (24.8)
Electronic equipment repair	2817 (9.3)	155 (8.7)	860 (9.3)
Communications/intelligence	2185 (7.2)	141 (8.0)	651 (7.0)
Health care	3950 (13.1)	131 (7.4)	686 (7.4)
Other technical and allied	776 (2.6)	40 (2.3)	218 (2.4)
Functional support and admin.	6674 (22.1)	230 (13.0)	1336 (14.4)
Electrical/mechanical equip. repair	3701 (12.3)	238 (13.4)	1540 (16.6)
Craft workers	841 (2.8)	41 (2.3)	317 (3.4)
Service and supply	2355 (7.8)	195 (11.0)	919 (9.9)
Students, trainees, and other	1142 (3.8)	111 (6.3)	441 (4.8)
Self-reported general health			
Fair/poor	2249 (7.5)	106 (6.0)	511 (5.5)
Good	9186 (30.4)	508 (28.7)	2698 (29.1)
Very good/excellent	18,755 (62.1)	1157 (65.3)	6055 (65.4)
Life stressors [†]			
Low/mild	25,234 (83.6)	1539 (86.9)	8134 (87.8)
Moderate	4022 (13.3)	203 (11.5)	977 (10.6)
Major	934 (3.1)	29 (1.6)	153 (1.6)

Table S1 continues on the following page

Table S1—Demographic, behavioral, and military characteristics by deployment status of 41,225 Millennium Cohort members (*continued*)

	No Deployment Before Follow-up Survey* n = 30,190 n (%)	Follow-up Survey During Deployment* n = 1771 n (%)	Follow-up Survey Postdeployment* n = 9264 n (%)
Baseline Characteristics			
Posttraumatic stress disorder	1170 (3.9)	64 (3.6)	265 (2.9)
Depression	870 (2.9)	50 (2.8)	183 (2.0)
Anxiety	554 (1.8)	28 (1.6)	136 (1.5)
Panic	356 (1.2)	15 (0.8)	62 (0.7)
Sleep apnea	840 (2.8)	32 (1.8)	200 (2.2)
Body mass index			
Mean	26.1	26.1	26.0
Underweight	246 (0.8)	8 (0.5)	60 (0.6)
Normal	10,797 (35.8)	601 (33.9)	3239 (35.0)
Overweight	15,629 (51.8)	983 (55.5)	5103 (55.1)
Obese	3518 (11.6)	179 (10.1)	862 (9.3)
Current smoker	4395 (14.6)	330 (18.6)	1549 (16.7)
Problem drinker [‡]	5589 (18.5)	368 (20.8)	1770 (19.1)
Follow-up Characteristics			
Combat [§]	NA	1010 (57.0)	4690 (50.6)
Posttraumatic stress disorder	1273 (4.2)	96 (5.4)	448 (4.8)
Depression	939 (3.1)	63 (3.6)	253 (2.7)
Anxiety	675 (2.2)	43 (2.4)	201 (2.2)
Panic	505 (1.7)	13 (0.7)	155 (1.7)
Children [¶]	1466 (16.7)	41 (14.9)	192 (11.8)

*At submission of follow-up survey, those in the nondeployed group had not yet deployed, those in the postdeployment group had completed at least 1 deployment, and those in the deployed group were currently deployed.

[†]History of life stress, including items such as divorce, assault, or having a family member die, was assessed by applying scoring mechanisms from the Holmes and Rahe Social Readjustment Rating Scale.

[‡]Problem drinking is defined as at least 1 positive response to the CAGE questions (i.e., Cutting down, Annoyance by criticism, Guilty feeling, and Eye-openers).

[§]At follow-up, had personally experienced combat or a combat-like situation, such as witnessing a person's death due to war, disaster, or tragic event.

[¶]Frequencies of women reporting having children in the last 3 years at baseline and follow-up.

Table S2—Adjusted* mean sleep duration at follow-up, the Millennium Cohort study (July 2004–January 2006)

Characteristics	Mean Sleep Duration at Follow-up n = 38,435		Baseline Characteristics	Mean Sleep Duration at Follow-up n = 38,435	
	Hours	P Value		Hours	P Value
Deployment status†		< 0.01	Occupational codes (<i>cont.</i>)		
Nondeployed	6.56		Health care	6.46	
Postdeployment	6.47		Other technical and allied	6.54	
Deployed	6.46		Functional support and admin.	6.52	
Baseline Characteristics			Electrical/mechanical equip. repair	6.53	
Sex		< 0.01	Craft workers	6.45	
Male	6.44		Service and supply	6.53	
Female	6.56		Students, trainees, and other	6.52	
Birth year		< 0.01	Self-reported general health		< 0.01
Pre-1960	6.56		Very good/excellent	6.55	
1960-1969	6.48		Good	6.50	
1970-1979	6.46		Fair/poor	6.44	
1980 and later	6.49		Life stressors‡		< 0.01
Race/ethnicity		< 0.01	Low/mild	6.59	
White, non-Hispanic	6.55		Moderate	6.47	
Black, non-Hispanic	6.43		Major	6.44	
Other	6.51		Posttraumatic stress disorder		0.27
Highest educational level		0.71	No	6.48	
Less than high school	6.51		Yes	6.52	
High school diploma/equivalent	6.48		Depression		0.08
Some college	6.50		No	6.54	
Bachelor's degree	6.50		Yes	6.46	
Advanced degree	6.51		Anxiety		0.67
Marital status		< 0.01	No	6.49	
Never married	6.50		Yes	6.51	
Married	6.46		Panic		0.35
Divorced, widowed, separated	6.53		No	6.53	
Service branch		< 0.01	Yes	6.47	
Army	6.42		Sleep apnea		0.74
Air Force	6.56		No	6.50	
Navy and Coast Guard	6.53		Yes	6.49	
Marine Corps	6.49		Body mass index		< 0.01
Service component		< 0.01	Normal	6.50	
Active duty	6.46		Underweight	6.59	
Reserve/National Guard	6.54		Overweight	6.46	
Military pay grade		0.13	Obese	6.44	
Officer	6.52		Current smoker		< 0.01
Enlisted	6.48		No	6.52	
Occupational codes		< 0.01	Yes	6.48	
Combat specialists	6.51		Problem drinker§		0.52
Electronic equipment repair	6.42		No	6.49	
Communications/intelligence	6.51		Yes	6.50	

*Model adjusted for all other variables in the table and baseline sleep duration (continuous).

†At submission of follow-up survey, those in the nondeployed group had not yet deployed, those in the Postdeployment group had completed at least 1 deployment, and those in the deployed group were currently deployed.

‡History of life stress, including items such as divorce, assault, or having a family member die, was assessed by applying scoring mechanisms from the Holmes and Rahe Social Readjustment Rating Scale.

§Problem drinking is defined as at least 1 positive response to the CAGE questions (i.e., Cutting down, Annoyance by criticism, Guilty feeling, and Eye-openers).

Table S3—Adjusted* odds of trouble sleeping at follow-up, the Millennium Cohort study (July 2004–January 2006)

n = 38,435			n = 38,435		
Baseline Characteristics	AOR	95% CI	Baseline Characteristics	AOR	95% CI
Deployment Status [†]			Occupation (<i>cont.</i>)		
Non Deployed	1.00		Functional support and admin.	1.00	(0.91, 1.08)
Post deployment	1.21	(1.14, 1.29)	Electrical/mech. equip. repair	0.97	(0.89, 1.06)
Deployed	1.28	(1.14, 1.43)	Craft workers	1.02	(0.87, 1.19)
Sex			Service and supply	1.05	(0.95, 1.16)
Male	1.00		Students, trainees, and other	1.08	(0.94, 1.24)
Female	1.56	(1.45, 1.67)	Self-reported general health		
Birth year			Very good/excellent	1.00	
Pre-1960	1.00		Good	1.66	(1.57, 1.76)
1960-1969	1.12	(1.05, 1.20)	Fair/poor	2.64	(2.40, 2.91)
1970-1979	1.15	(1.06, 1.25)	Life stressors [‡]		
1980 and later	1.39	(1.19, 1.62)	Low/Mild	1.00	
Race/ethnicity			Moderate	1.51	(1.41, 1.63)
White, non-Hispanic	1.00		Major	1.97	(1.71, 2.28)
Black, non-Hispanic	0.74	(0.68, 0.81)	Posttraumatic stress disorder		
Other	0.90	(0.84, 0.97)	No	1.00	
Highest educational level			Yes	2.39	(2.08, 2.76)
Less than high school	1.00		Depression		
High school diploma/equivalent	0.95	(0.85, 1.07)	No	1.00	
Some college	0.88	(0.78, 0.99)	Yes	2.12	(1.78, 2.52)
Bachelor's degree	0.87	(0.76, 1.00)	Anxiety		
Advanced degree	0.96	(0.82, 1.13)	No	1.00	
Marital status			Yes	2.08	(1.67, 2.60)
Never married	1.00		Panic		
Married	0.99	(0.92, 1.06)	No	1.00	
Divorced, widowed, separated	0.97	(0.86, 1.08)	Yes	2.20	(1.68, 2.87)
Service branch			Sleep apnea		
Army	1.00		No	1.00	
Air Force	0.75	(0.70, 0.80)	Yes	1.59	(1.38, 1.83)
Navy and Coast Guard	0.73	(0.68, 0.78)	Sleep duration (continuous)		
Marine Corps	0.92	(0.81, 1.03)	1-hr increase	0.80	(0.78, 0.81)
Service component			Body mass index		
Active duty	1.00		Normal	1.00	
Reserve/National Guard	0.92	(0.87, 0.98)	Underweight	0.96	(0.71, 1.28)
Military pay grade			Overweight	1.03	(0.97, 1.09)
Enlisted	1.00		Obese	1.00	(0.92, 1.10)
Officer	0.83	(0.75, 0.91)	Current smoker		
Occupation			No	1.00	
Combat specialists	1.00		Yes	1.16	(1.09, 1.24)
Electronic equipment repair	1.14	(1.03, 1.25)	Problem drinker [§]		
Communications/intelligence	0.96	(0.86, 1.06)	No	1.00	
Health care	1.08	(0.98, 1.20)	Yes	1.50	(1.41, 1.59)
Other technical and allied	0.99	(0.84, 1.17)			

CI, confidence interval; AOR, adjusted odds ratio.

*Model adjusted for all other variables in the table.

[†]At submission of follow-up survey, those in the nondeployed group had not yet deployed, those in the postdeployment group had completed at least 1 deployment, and those in the deployed group were currently deployed.[‡]History of life stress, including items such as divorce, assault, or having a family member die, was assessed by applying scoring mechanisms from the Holmes and Rahe Social Readjustment Rating Scale.[§]Problem drinking is defined as at least 1 positive response to the CAGE questions (i.e., Cutting down, Annoyance by criticism, Guilty feeling, and Eye-openers).